

Guidance for Monitoring and Mitigating Exposure to Carbon Monoxide and Particulates at Incident Base Camps

Current Status:

The current exposure levels of incident personnel to carbon monoxide (CO), particulate matter, and other respiratory irritants in wildfire smoke are similar to the levels quantified by Ottmar and Reinhardt in the early 1990s [reference – per previous doc: Reinhardt, T.E., and R.D. Ottmar. “Baseline Measurements of Smoke Exposure Among Wildland Firefighters”. Journal of Occupational and Environmental Hygiene 1:593-606 (2004)]. Recent data collected by Broyles and colleagues (San Dimas Technology and Development Center), confirms that overexposure to respiratory irritants is primarily due to elevated short duration smoke exposures.

The Federal Occupational Safety and Health Administration (OSHA) and state laws prohibit exposing employees to hazards exceeding applicable occupational exposure limits (OELs). These limits are applicable in routine and emergency settings. Because recent data confirms overexposures to respiratory irritants do occasionally occur in the dynamic fire environment, respective wildland fire agencies must implement mitigation measures to mitigate these exposures.

Recommended Exposure Level Ranges for Fireline Operations:

The current OSHA permissible exposure limit is 50 parts per million (ppm) for an 8 hour work day. However, wildland firefighter work shifts are typically much longer, often 12-13 hours. Based on the best available science to date, the Smoke Exposure Task Group (SETG) and their group of leading researchers from across the United States established an exposure recommendation for wildland fireline operations to be:

- Carbon monoxide of 8 ppm for a 24 hour period and
- 16 ppm for a 13 hour work shift

The multi-year (2009 – 2011) smoke study data indicates the average CO exposure is just under 3 ppm for wildfire operations and slightly above the 3ppm for prescribed fire and 95% of shift exposures were below 17 ppm. Based on the work by Reinhardt and Ottmar referenced above, CO can be used as a surrogate for respiratory particulate near the combustion source. At locations away from the combustion source the relationship between CO and respiratory particulates decreases. Data from 2011 to better define the decrease in relationship between CO and respiratory particulates away from the combustion source is still being analyzed.

Most Common Over Exposure Fireline Tasks:

Based upon the on-sight smoke field studies, there was approximately 5% of firefighters who had an overexposure during an average work shift. The following fireline tasks are identified as having the greatest potential for smoke/CO over exposure:

- Mop-up
- Fireline holding
- Saw operations (combined exposure from smoke and saw exhaust)

Recommended Exposure Level Ranges for Incident Base Camp Operations:

Incident base camp personnel are demographically similar (e.g., age, weight, gender, health status) to the general adult population and the recommended exposure range matches that of the Environmental Protection Agency (EPA) based upon particulate matter (PM) and stated below:

- 35.5-80.4 24-Hour BAM($\mu\text{g}/\text{m}^3$)

At risk factors for smoke exposure within the general public also apply to incident base camp personnel, which include, but not limited to; cigarette smoking, cardio vascular disease, high blood pressure and obesity.

Signs and Symptoms Associated with Carbon Monoxide Exposure

Table 1 identifies signs and symptoms that typically occur with exposure to carbon monoxide. It should be noted that these symptoms can vary by individual and predisposition to smoke exposure. For example, cigarette smokers show fewer symptoms than a non smoker with similar CO exposure.

Mitigation Recommendations:

The SETG determined that several of the mitigation measures recommended in the 1997 report, *The Health Hazards of Smoke*, are not currently being implemented, or there is no documentation of implementation. In 2010, interagency fire management and operational personnel developed a revised list of recommendations to mitigate employee smoke overexposure. The smoke exposure task group ranked the measures according to their potential effectiveness and the practicality of their implementation. The top recommended mitigations are shown in table 2. These recommendations constitute the administrative controls that OSHA regulations and agencies' policies require before fire management can implement the use of PPE.

Respiratory Protection:

As stated above, OSHA regulations and agencies' policies preclude the use of personal protective equipment (in this case respirators) until alternative engineering and administrative controls are found to be ineffective or infeasible. Respirators may be useful in limited circumstances, but they impose a physiological burden on the wildland firefighter which could lead to unintended health illnesses. If implementation becomes necessary, agencies must establish a written respiratory protection program, and respirators must be approved by NIOSH and comply with *NFPA 1984 Standards on Respirators for Wildland Fire Fighting*. To date, there are no respirators for wildland firefighters that meet these requirements and when/if they become available, physiological burdens will still exist. It is also noted that if appropriate controls and mitigations are implemented (as in Table 2), then the use of respiratory protection should not be warranted. With that, the Risk Management Committee at this time does not recommend the use of respiratory protection for the wildland fire environment and fire managers should focus on mitigation implementation.

Table 1: Signs and Symptoms Associated with Carbon Monoxide Exposure

*CO in atmosphere (ppm)	COHb in blood (%)	Signs and symptoms
10	2	Asymptomatic
70	10	No appreciable effect, except shortness of breath on vigorous exertion; possible tightness across the forehead; dilation of cutaneous blood vessels.
120	20	Shortness of breath on moderate exertion; occasional headache with throbbing in temples
220	30	Headache; irritable; easily fatigued; judgment disturbed; possible dizziness; dimness of vision.
350-520	40-50	Headache, confusion; collapse; fainting on exertion
800-1220	60-70	Unconsciousness; intermittent convulsion; respiratory failure, death if exposure is long continued
1950	80	Rapidly fatal

* Symptoms may appear with less CO exposure due to other irritants in smoke

Source: (Winter and Miller, 1976; Ellenhorn and Barceloux, 1988) in Fierro et al, 2001.

Table 2: Recommended mitigations for reduction of smoke exposure

It is important to note that smoke is just one of the potential risks faced by wildland firefighters. When instituting these recommendations it is important to evaluate and balance all the risks associated with the operational objective. The following recommended mitigations are not intended to be used in sequential order, but individual or combined mitigations that can be applied based upon potential or actual onsite smoke hazards identified.

<p>Exposure Mitigations for <u>Fireline Operations</u>:</p> <ul style="list-style-type: none"> • Minimize mop-up whenever possible, utilizing alternative means with less exposure.
<ul style="list-style-type: none"> ➤ Use time and patience to put the fire out: <ul style="list-style-type: none"> ▪ allow secured areas to burn out ▪ rely on burn-up instead of mop-up ▪ use dozers or other mechanical equipment to spread out burn piles
<ul style="list-style-type: none"> ➤ Adjust operational periods on mop-up to avoid periods of inversion.
<ul style="list-style-type: none"> ➤ Adjust prescriptions during prescribed fire where possible to reduce smoke by providing more complete combustion.
<ul style="list-style-type: none"> ➤ Minimize snag falling as long as all other safety concerns are mitigated.
<ul style="list-style-type: none"> • In heavy smoke conditions, consider establishing control lines where conditions allow for less smoke exposure to firefighters, even if more acreages is burned.
<ul style="list-style-type: none"> • Rotate personnel out of heavy smoke areas
<ul style="list-style-type: none"> • Use equipment rather than people when possible in holding areas (sprinklers, retardant, foam, etc).
<p>Exposure monitoring for <u>Fireline Personnel</u>:</p> <ul style="list-style-type: none"> • NWCG is developing a surveillance plan and if an agency/IMT wants to perform monitoring in the meantime, utilize exposure ranges as previously stated and follow the current American Conference on Governmental Industrial Hygienist (ACGIH) monitoring guidelines. Monitoring equipment will need to be acquired through specific agency channels.
<p>Exposure Mitigations for <u>Incident Personnel at Base Camps</u>:</p> <ul style="list-style-type: none"> • Locate camps and Incident Command Posts in areas that are not prone to inversions or upwind of fire. Utilize spike camps as alternatives to impacted camps. • Utilize facilities with filtered air systems
<p>Exposure Monitoring for <u>Incident Base Camps</u>:</p> <ul style="list-style-type: none"> • Fire camp Smoke Monitoring Kits are available in the national cache system, NFES 5840. These systems come with easy to follow directions. Currently the National/Great Basin cache stocks 15 Kits that can be order through Resource Ordering and Status System (ROSS) (see attached ordering process).
<p>Additional Mitigations for <u>Incident Base Camp and Fireline Operations</u>:</p> <ul style="list-style-type: none"> • Include smoke hazards on the Incident Action Plan Safety Analysis, ICS-215A worksheet, at planning and briefing sessions, and adjust operations accordingly.
<p>Address smoke impacts in job hazard analysis/risk assessments:</p> <ul style="list-style-type: none"> • Need to reinforce the inclusion of smoke exposure and mitigation methods

If you have any questions, please contact your respective agency RMC representative at:
<http://www.nwcg.gov/branches/pre/rmc/contactus.htm>